THE D/H RATIOS OF ROUND PHYLLOSILICATE AND GLASS SPHERULES IN THE AL RAIS (CR) CHONDRITE.

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It is well known that many primitive meteorites and interplanetary dust particles (IDPs) exhibit large D enrichments relative to terrestrial material. While the dominant carrier of D excesses in most meteorites is proved to be an acid-resistant organic phase, several studies[1,2,3] indicated that water is probably another D-rich carrier and that some primitive meteorites may still contain sample of interstellar water that survived into the Solar System. Phyllosilicates found in CR meteorites provide one of the best candidates for direct survey of the D/H ratios of water in meteorites.

A previous study[4] demonstrated that the yellow and brown spherules noted in CR chondrites are non-crystalline material (glass), phyllosilicates, or a mixture of both. These spherules, generally smaller than 1 mm, are found within and rimming chondrules, and scattered loosely within matrix. They are particularly abundant in Al Rais. Six of these spherules (less than 100 μm) were selected from Al Rais and pressed into a Au foil for D/H measurement with an ion microprobe. After the isotopic analysis, the unsputtered part of these samples were removed from the Au foil and examined by transmission electron microscopy (TEM) for their mineralogical characteristics.

The results are listed in Table 1. Except for one fragment (ALRS-1A), all the other spherules or fragments exhibit obvious D excesses (δD = +201 to +798‰) relative to terrestrial materials. Compared to the bulk Al Rais (δD ranging from +520 to +690‰)[5,6], these spherules show larger range in δD values.

Fragment ALRS-1A has a normal hydrogen isotopic composition (δD=-49‰). Surprisingly, ALRS-1B, designated as a duplicate fragment from the same spherule as ALRS-1A, shows a much higher δD value (+521‰). Another pair of duplicate fragments, ALRS-4A and ALRS-4B, have similar D/H ratios. Also, no variation larger than analytical uncertainty was observed during multiple measurements of each other spherule or fragment. Further examination showed that ALRS-1A was probably mis-identified in the ion probe analysis. ALRS-1A and ALRS-1B are not fragments from the same spherule ALRS-1 and the large difference in their δD values does not indicate heterogeneous distribution of D-enrichments. ALRS-1A is most probably a terrestrial contaminant.

Except for ALRS-1A and ALRS-1B, which have little unsputtered material left, all other fragments were successfully removed from the Au foil and examined by TEM after ion probe analysis. Spherules ALRS-2 and ALRS-6 are identified as glass, while the others are phyllosilicate spherules composed mainly of serpentine with accessory saponite. Compared to the two glass spherules, it is interesting to note that the phyllosilicates had relatively higher δD values. Though these values are substantially lower than the large D excesses obtained by stepwise pyrolysis for the ordinary chondrites Semarkona and Bishunpur[1,3], they are close to those (δD^3+730‰) suggested for phyllosilicates in Renazzo (CR) matrix[2,]. According to a previous study[4], the spherules in Al Rais are almost undoubtedly glassy, pre-accretionary objects caught in various stages of aqueous alteration. The extremely homogeneous texture of phyllosilicates supports the contention that they derive from such a homogeneous siliceous glass, as opposed to merely a fine-grained assemblage of anhydrous, crystalline silicates. The higher δD values in the phyllosilicate spherules imply that the water introduced during the aqueous alteration is highly D-enriched. The largest D excess (δD=+798‰) observed in ALRS-2 may represent the lower limit for the D/H of the water source.

The origin of the large D excesses in primitive meteorites has been extensively discussed[7] and it is believed that they are due to ion-molecule reactions in an cold, molecular cloud environment prior to the formation of the Solar System. The highly D-enriched water, which interacted with siliceous glass to form phyllosilicate spherules in Al Rais, should also originate from a similar interstellar environment.

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Table 1 D/H Ratios of Spherules from Al Rais

Sample	Mineralogy	δD (‰SMOW)	Error of Mean	Spots Analyzed
ALRS-1A	?	-49	24	4
ALRS-1B	?	521	29	4
ALRS-2	phyllosilicate	798	27	4
ALRS-3	glass	201	13	6
ALRS-4A	phyllosilicate	478	27	4
ALRS-4B	phyllosilicate	532	41	2
ALRS-5	phyllosilicate	608	20	7
ALRS-6	glass	326	30	4

? --- No TEM identification; A , B --- designate duplicate fragments from same spherule